High resolution photoemission experiments on a two-dimensional Fermi liquid: $TiTe_2$

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The concept of the Fermi liquid is at the heart of present day solid state physics. In short this concept means, that electrons in a metallic system can be related to those of an independent electron metal by a one-to-one relation. This is by no means trivial because electron-electron interactions are often large in metals. Since the treatment of electron-electron interactions in metals, which are very many particle systems, is so difficult the concept of the Fermi liquid is so valuable. It in essence means that the properties of the electrons in the real metal are renormalized with respect to those of the independent electron metals and the respective many-body excitations are then called "quasi particles". For excitations near the Fermi energy the renormalization of the energy of the independent particle electrons with respect to the quasi particles in their real system can be described by a complex self energy $\Sigma(\mathbf{k}, E)$ which follows the relation:

$$\Sigma(E) = \mathrm{a}E + \mathrm{ib}E^2 \tag{1}$$

(where E is the energy relative to the Fermi energy), meaning in particular, that we have a finite lifetime of the quasi particle excitations given by $\mathrm{Im}\Sigma$ and a renormalization of the energy position described by $\mathrm{Re}\Sigma$. As a matter of fact one often turns around and defines a Fermi liquid by the fact that the self energy behaves in the method just outlined.

Judging its importance it is surprising that especially the imaginary part of the self energy in the Fermi liquid is not very well documented experimentally. To that point there have been investigations of surface states [1] and of one particular two-dimensional metal, namely $TiTe_2$ [2], where especially the latter investigation was not performed with the best possible resolution. Two-dimensional systems are almost mandatory for the investigation of the imaginary part of the quasi particle lifetime because they allow one to extract in a dircet manner the lifetime width from the measured spectra [3].

At the high resolution and low temperature beamline 10.0.1.1 at the ALS an effort was made to get data for the quasi two-dimensional metal $TiTe_2$ at ≈ 10 K, where thermal broadening is negligible. Although long runs with different crystals have been performed so far the results are not completely convincing and good fits to the Fermi liquid line shape could only be obtained for data taken very near to the Fermi energy.

Figure 1 shows the best experimental data obtained so far and a fit using a two pole ansatz for the self energy function $\Sigma(\mathbf{k}, E)$ [4], the Taylor expansion of which for $E = 0$

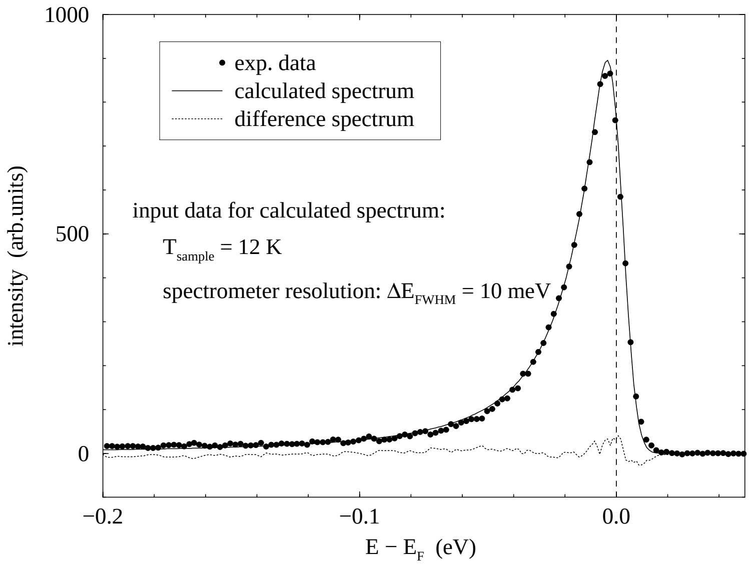

Figure 1: *Angle resolved photoemission spectrum of* $TiTe_2$ *(filled circles), calculated spectrum (solid line) and difference spectrum of both (dotted line) for the emission angle where the quasi particle excitation is closest to the Fermi energy.*

obbeys equation 1. The agreement between theory and experiment is very gratifying. However, looking at the data away from the Fermi wavevector the fits become much worse and at present it is not obvious what the reason for this problem is. Therefore more effort to analyse the existing data will be necessary and in addition new sets of data will have to be accumulated, because an influence of the sample quality can not be ruled out.

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